Progress with Bialkali Photocathode Development at SSL

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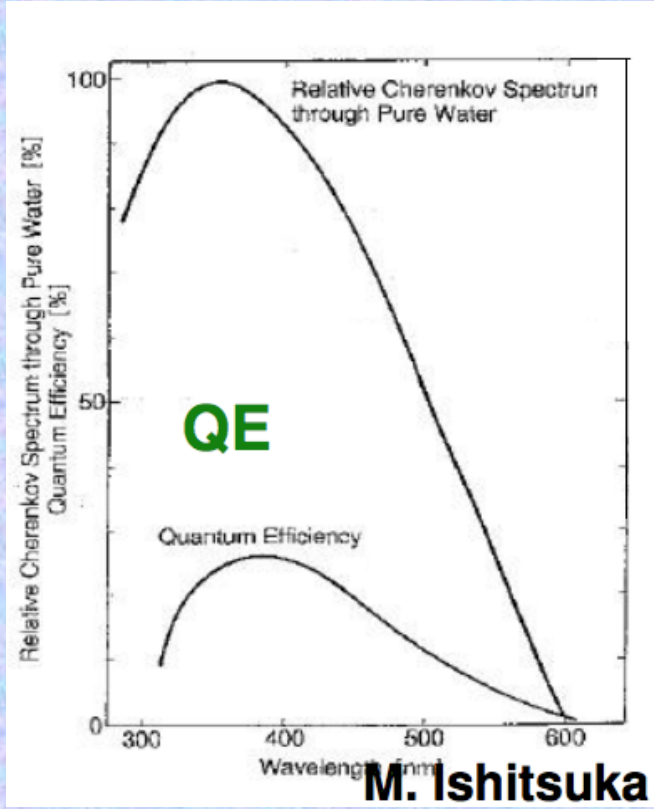
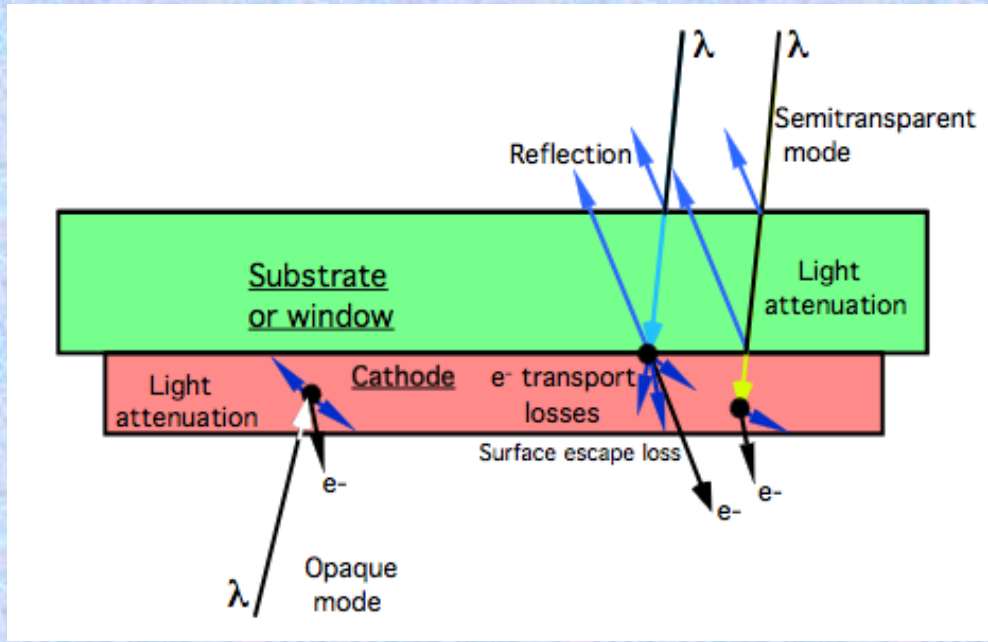
Biakali Cathode - Configurations



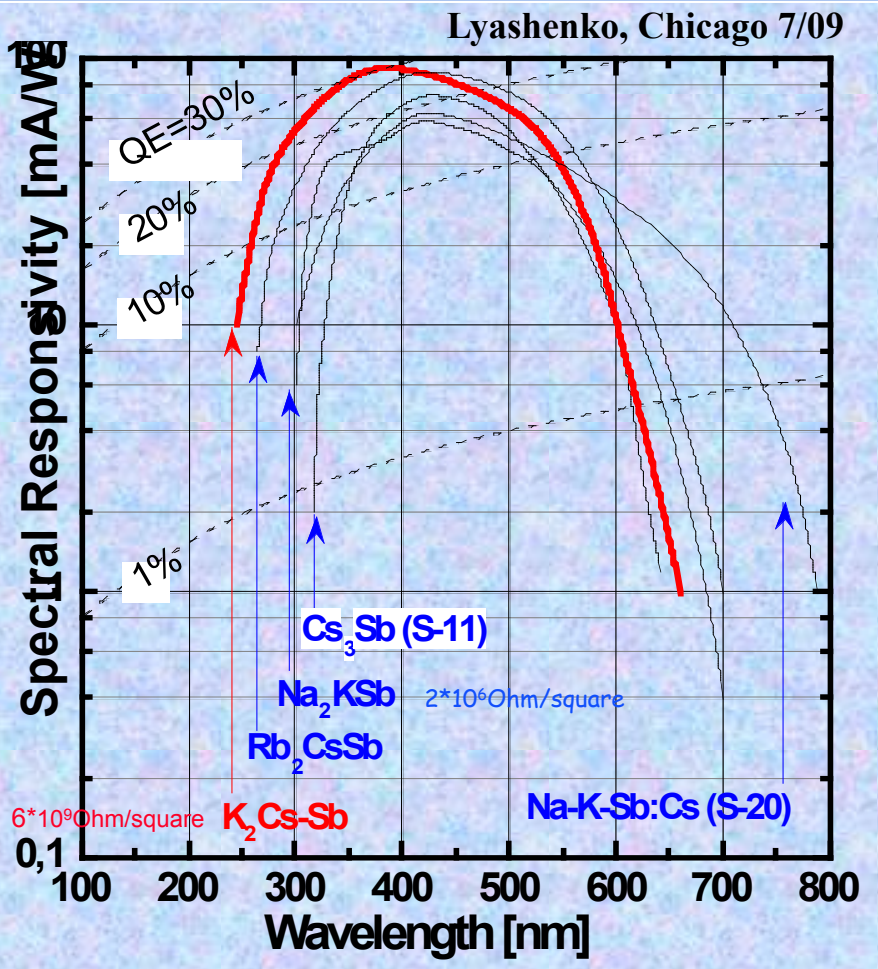
Nominal Cherenkov emission spectrum compared with bialkali

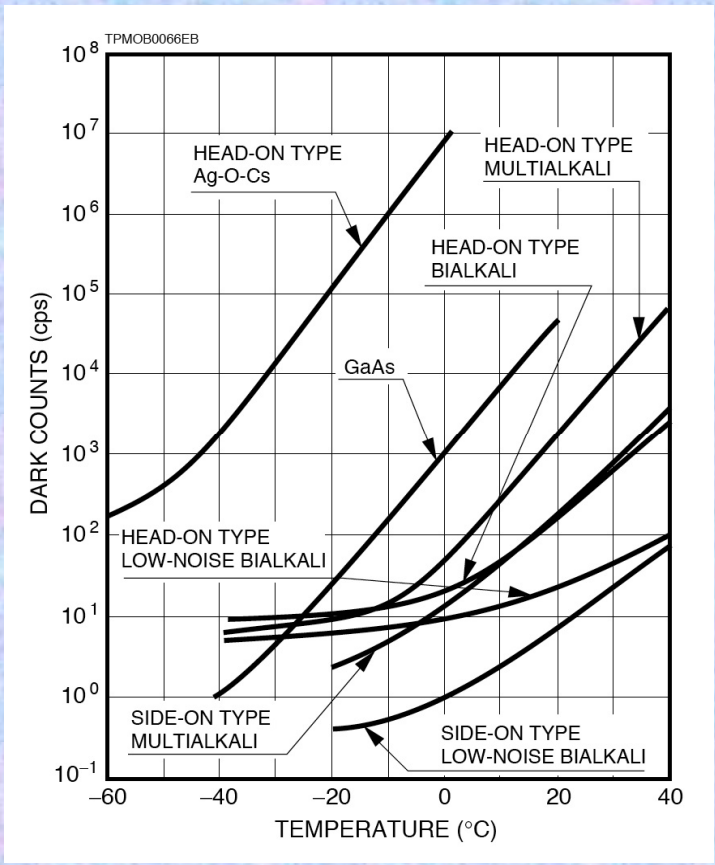
Photocathode Operation Schemes

Bialkali is a few 100Å thick, and is nominally a deposition as a semitransparent layer on the window, with a proximity gap to the first MCP.



Typical Bi-Alkali Cathode Characteristics



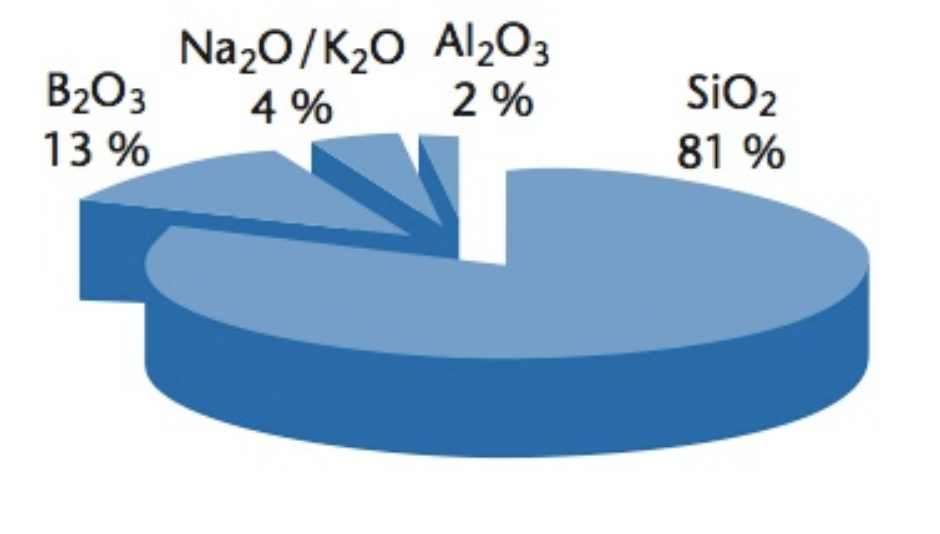


QE and resistivity for various bialkali's We will use Na_2KSb – Why? Resistivity, noise, temperature robustness, uniformity.

Cathode Noise vs Temp expect 10,000 to 40,000 events/sec for 8" tube bialkali!

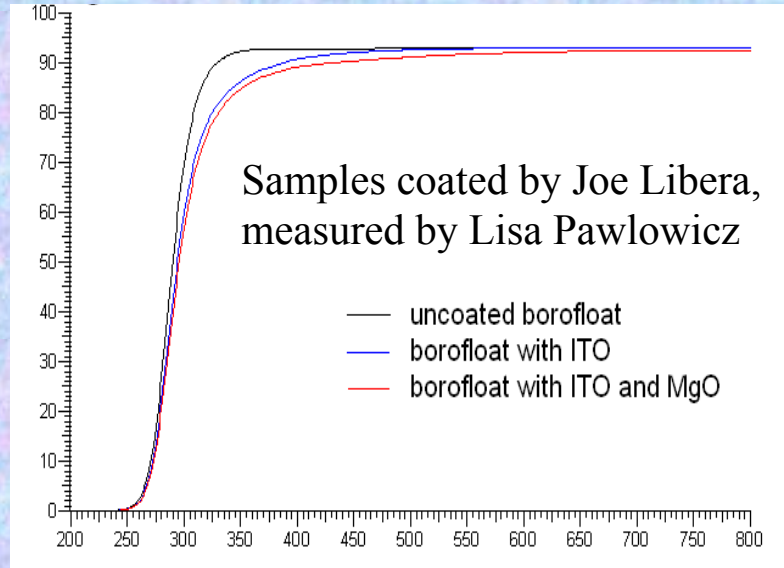
Window of choice B33 - General Parameters

The cathode substrate, window or window coating, affects the photocathode performance. Borofloat B33 Borosilicate has been tested, and it is a good photocathode substrate. BUT - it has Tin diffused into one side, so we polish it. Anti-reflection coatings not baselined, (5 to 9% reflectance in bandpass).



B33 Composition

Refractive index—@400nm	
B33	1.47
Air	~1.0
Water	~1.32



B33 Transmittance is typical of boro-silicate glasses.

Bialkali Cathode Development Program

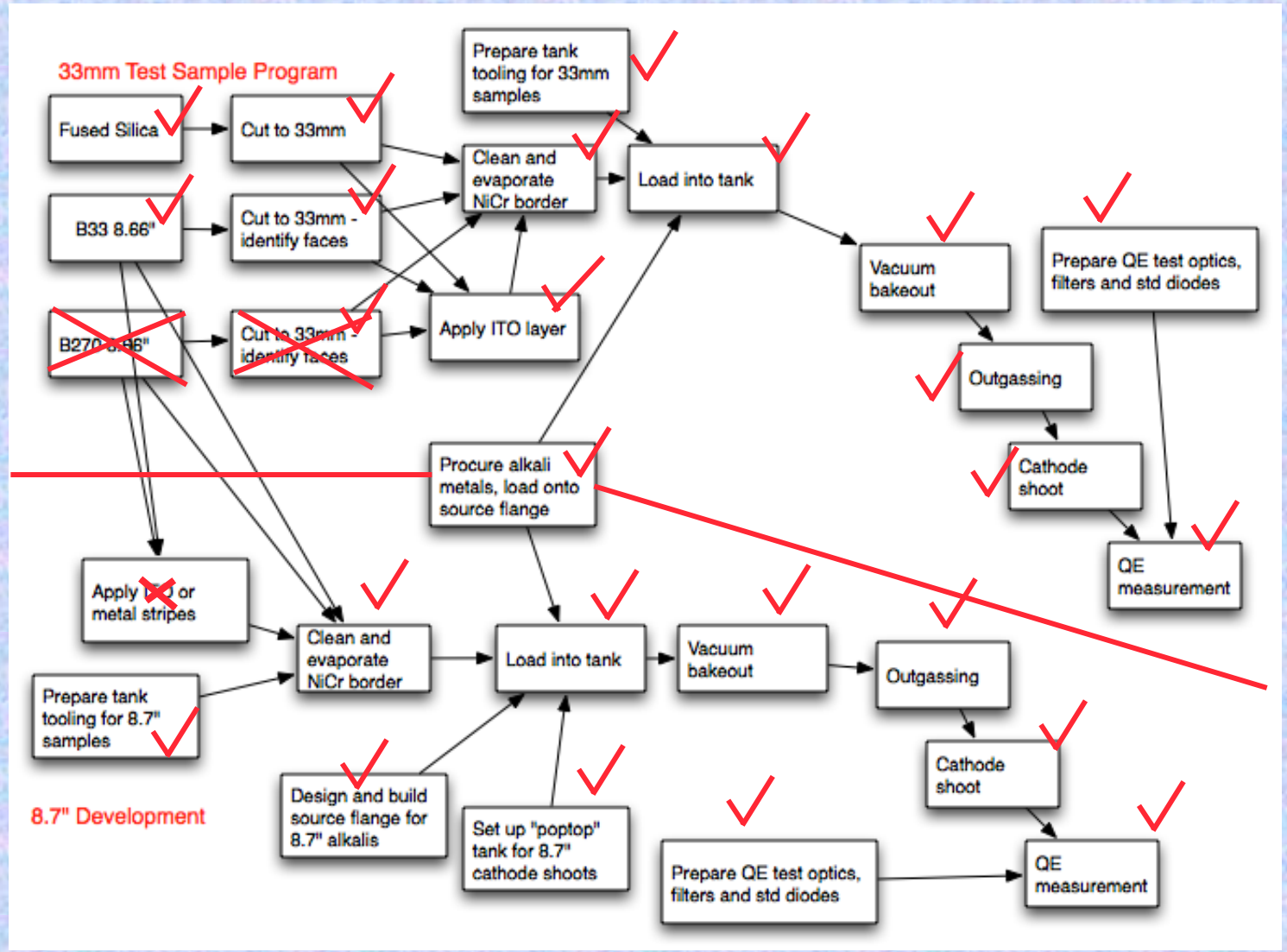
Small window cathode development, 1.22” samples, 4 per run

- **Processed samples to optimize QE and bandpass**
  - **Studied Na_2KSb, K_2CsSb cathodes**
- **Used several substrate materials, SiO_2, verified B33**
- **Tested MgO/ITO/conductor underlayer for cathodes**

Large size window cathode study, 8.7” windows.

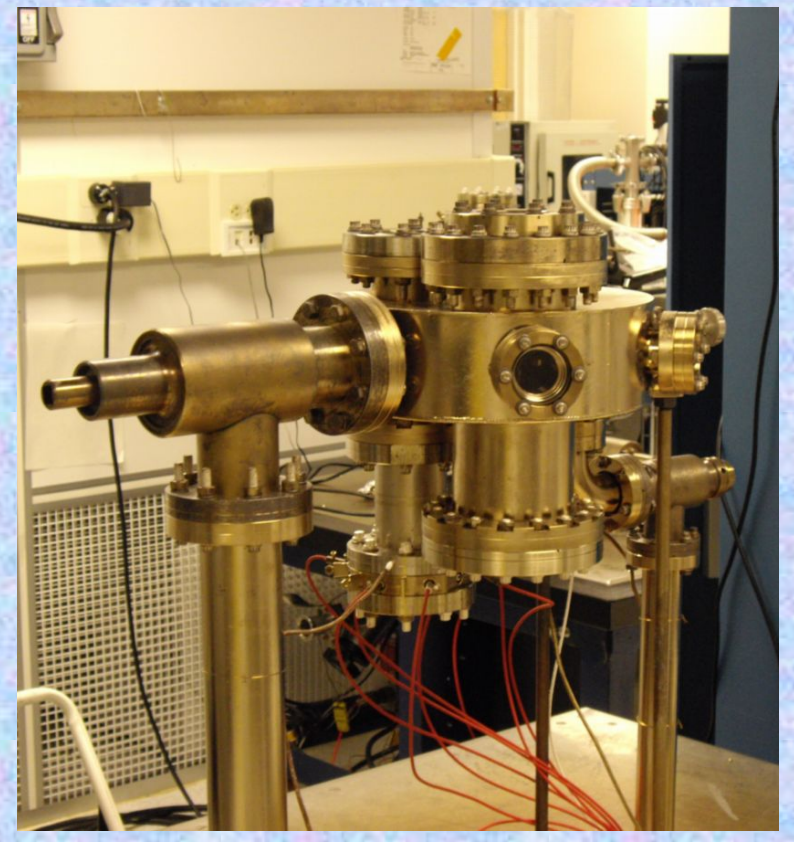
- **Developed source alkali design for large cathodes**
- **Developed techniques to make larger area uniform QE**
- **Optimization of cathode QE levels successful**
- **No metal conductor under-layer is needed**
- **Use “X” conductor pattern matching tube hardware**
- **Testing window metalization and sealing techniques**

Work Flow Program for Bialkali Cathode Development



We have run all the processes. Now we need to make the 20cm depositions in the large tube process tank.

Tube Lab, 1.2” old sample test/process station.



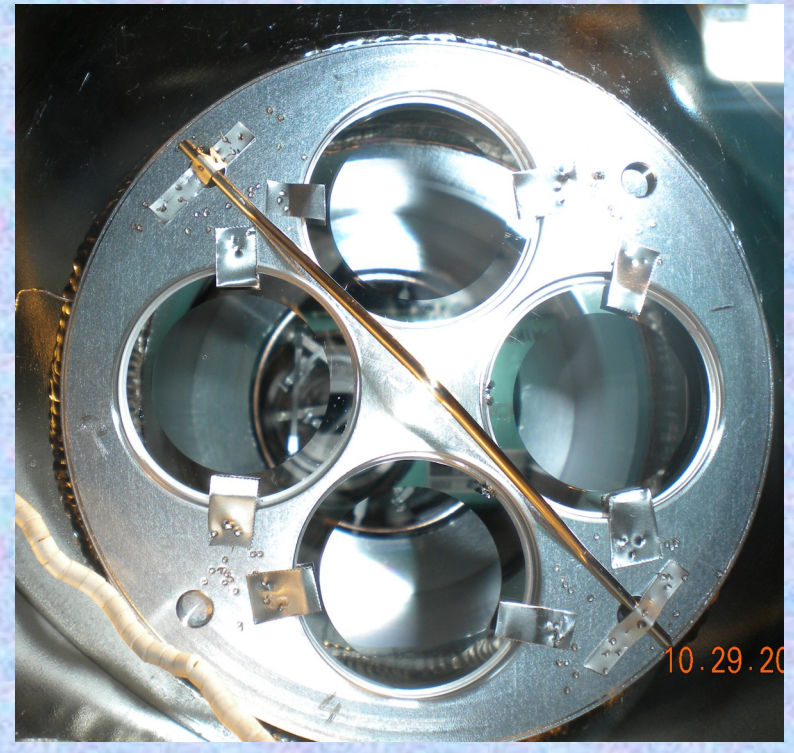
Small tank used to process alkali cathodes (33mm) and tubes of small area. Can take 4-8 samples/run. 7 runs done, more than 30 substrate coatings.

- **Small sample test runs**
- **Substrate material tests**

Bialkali Cathode Process Development Program

Small window cathode development, 1.22” samples
- Processed samples to optimize QE and bandpass

Window holder inside tank

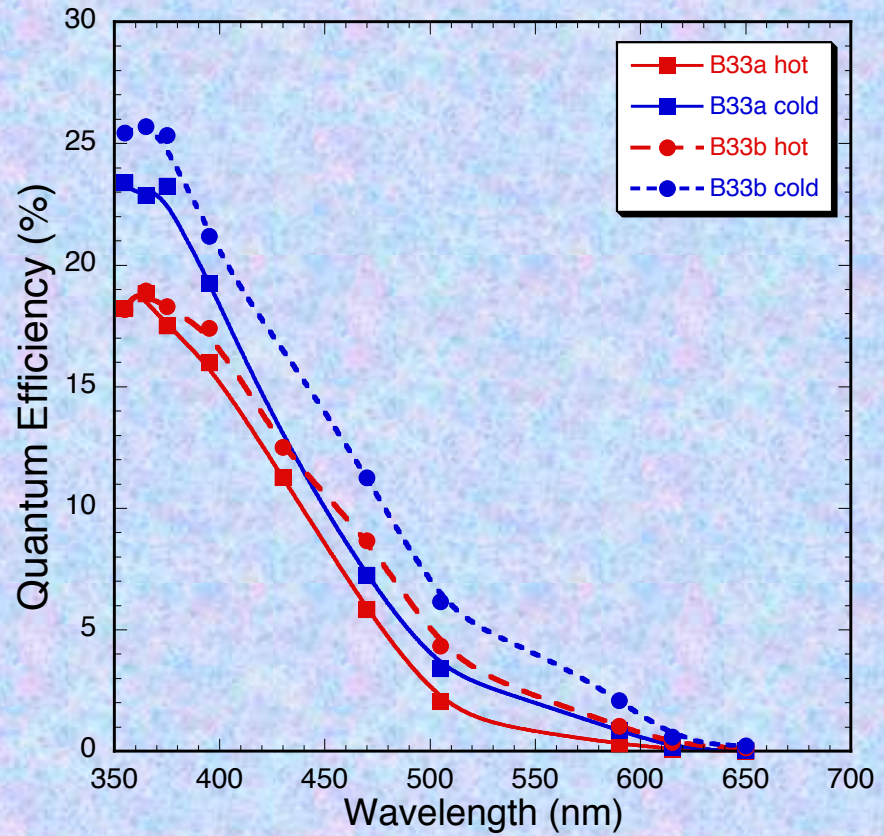


Window holders and mask

We cut up 8.7” B33 windows to make ~50 ea 1.22” test samples.
Inconel annular electrodes were evaporated just as they would be for In seals

Bialkali Photocathode Sample Tests

Cathode test runs with KCsSb and Na_2KSb cathodes on borofloat-33 windows. Na_2KSb ~25% QE achieved, QE uniformity better than ± 15%.



Bialkali test cathodes made on polished 31mm B33 windows gave the best results. Na_2KSb measured hot, right after deposition, always improves after cool down. Have been able to repeat the process a number of times in different process tanks too.

Small Cathode/Substrate Materials Summary

- ITO and MgO, 5nm are QE are not useful – poor QE
- No problems with inconel evaporated borders good adhesion/conduction
- K_2CsSb cathode fabrication is problematic, lower temp tolerance, poor conductivity, more noise.
- B33 is a good substrate material

- Work with Na_2KSb as baseline, use Inconel conductor arranged on same "X" as support. B33 ok for rigorous cleaning, high temp, stable, uniform, high conductivity, good QE.

8” Cathode Process Development

Large window cathode development, 8.7” square

- Commissioned 8” cathode/window seal process tank

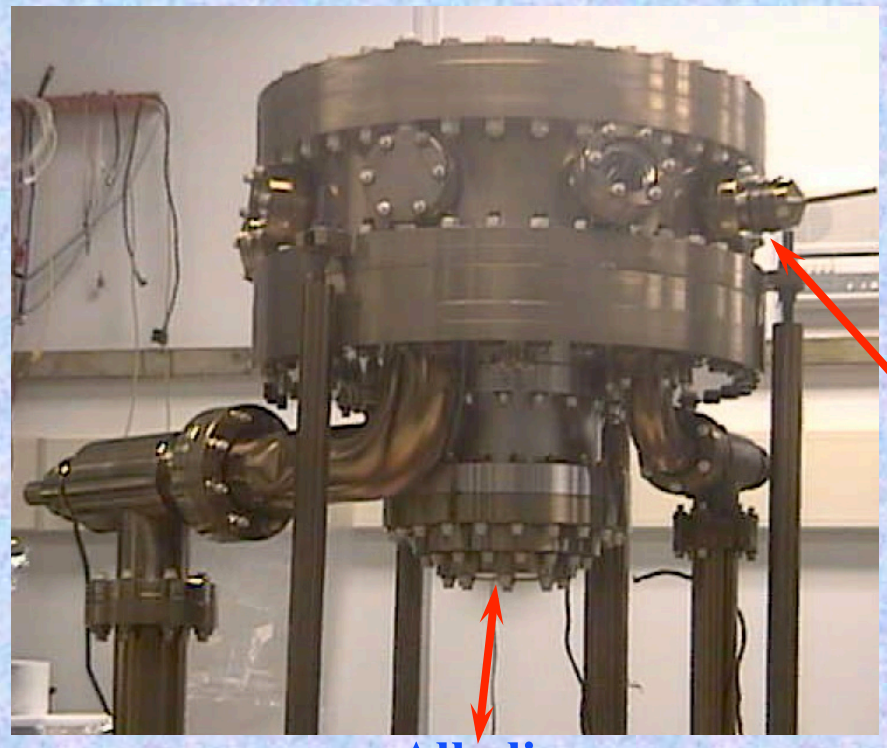
Objectives:-

- Copy small sample deposition method for verification
- Optimize alkali sources for large cathode areas
- Confirm 8” wet cleaning and plasma cleaning processes
- Test metal stripe underlayers for cathodes
- Optimize cathode QE levels and test stability and uniformity
- Trial window seals on 8.7” “frames”

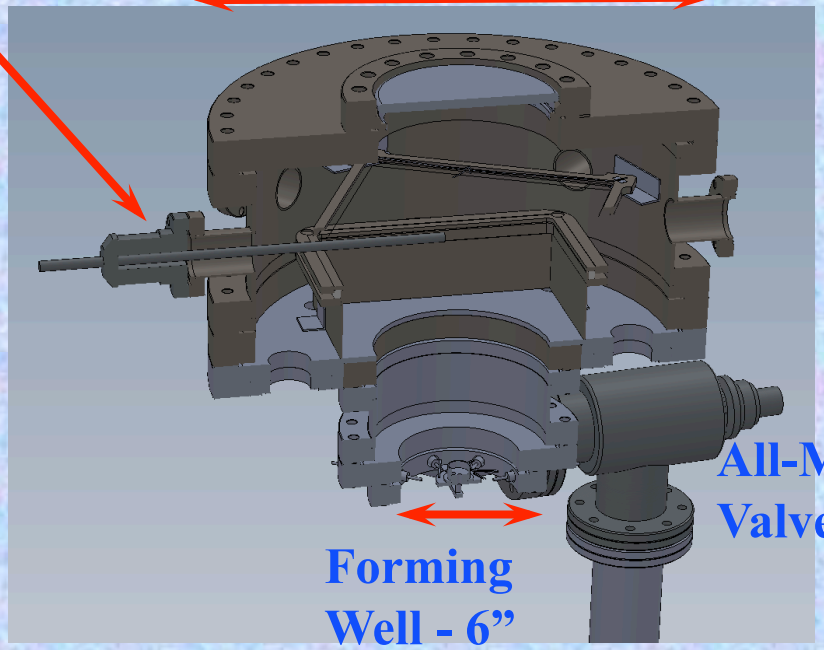
- Next:-----
- Transfer techniques to large tube processing station

8.7” Photo-Cathode / Seal test Chamber

8.7” Square PC/seal test process chamber with 14” Dia. Capability 16.5” Dia. Chamber on same process cart as the previous chamber.



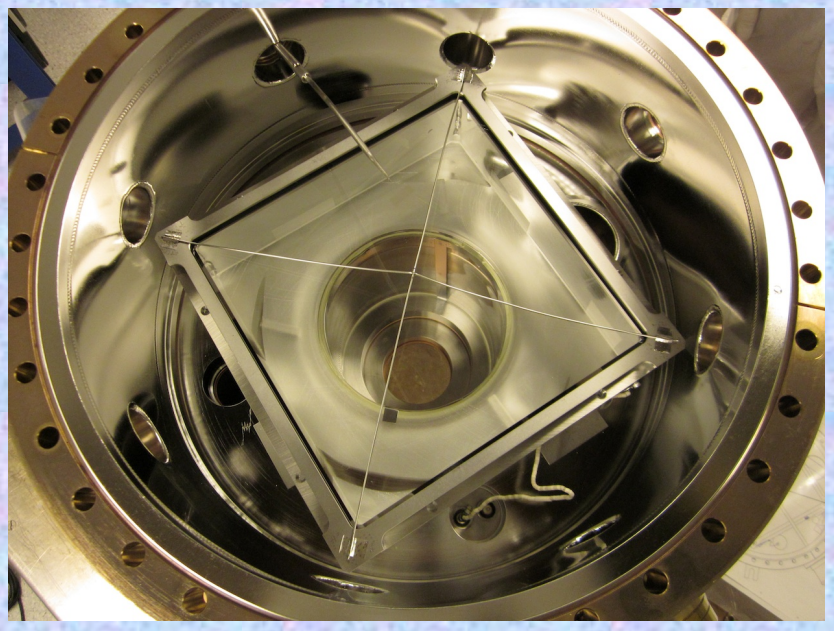
Alkali sources



Larger 16” flange tank, for testing

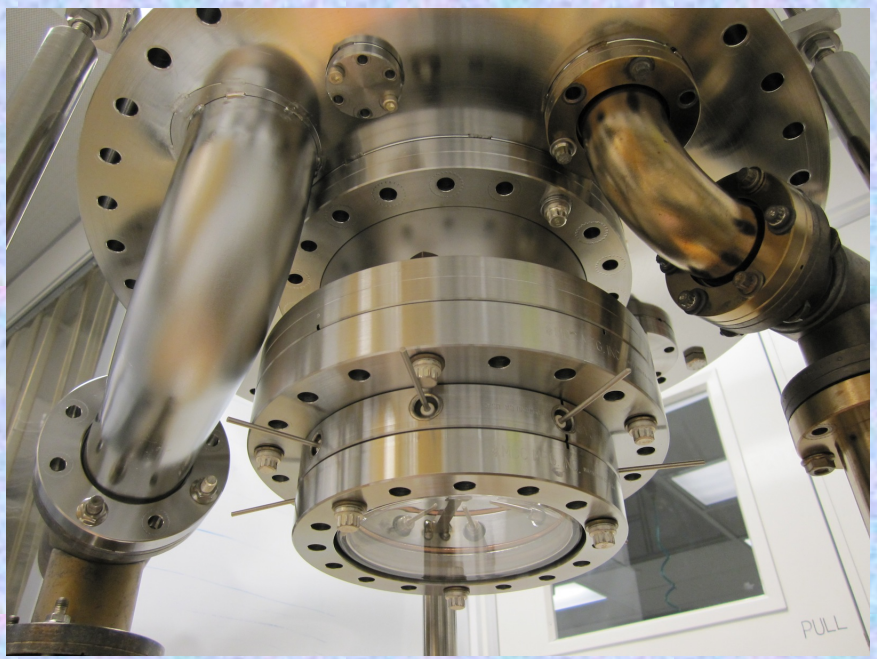
- **-Quantum efficiency**
- **-QE Uniformity**
- **-Seal tests**

8.7” Photo-Cathode / Seal test Chamber

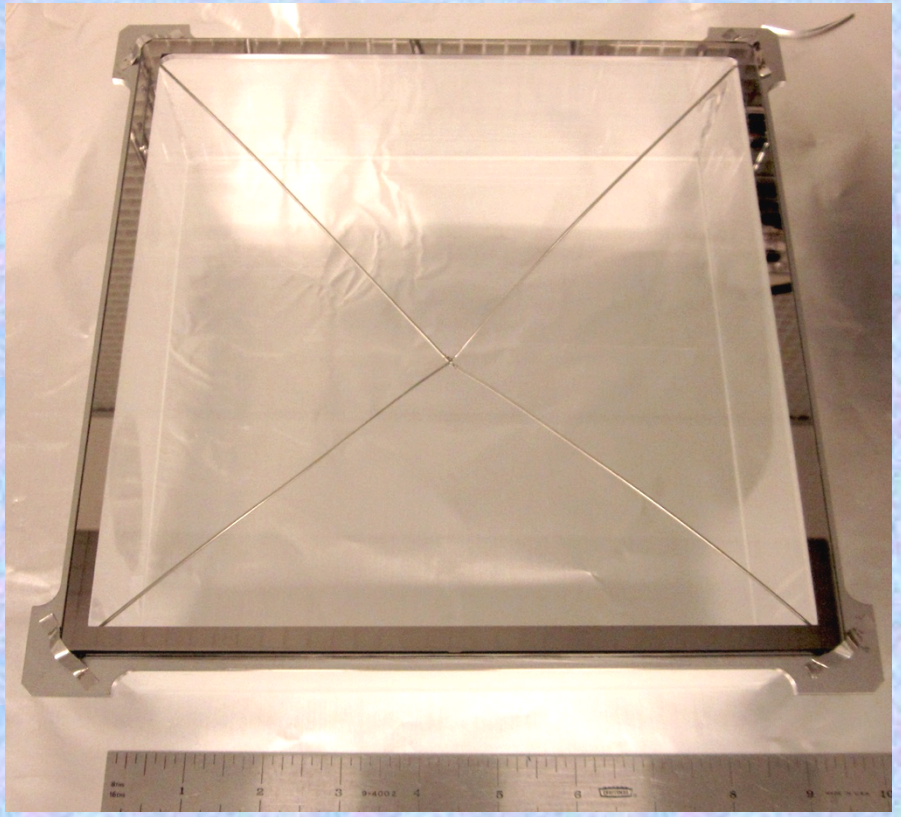


Final assembly done, spent 3 weeks in initial cleanup bakeout up to 375°C to get the chamber conditioned.

Used SAES alkalis & SbPt beads. Employed old source flange to verify process, then we moved to new larger sources for next run.

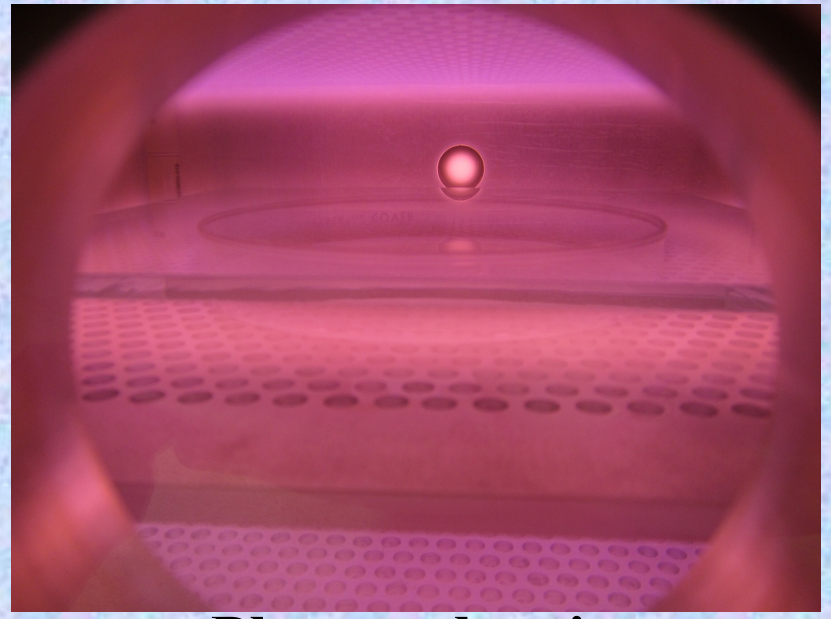


Preparation of 8.7” B33 Windows for Cathodes



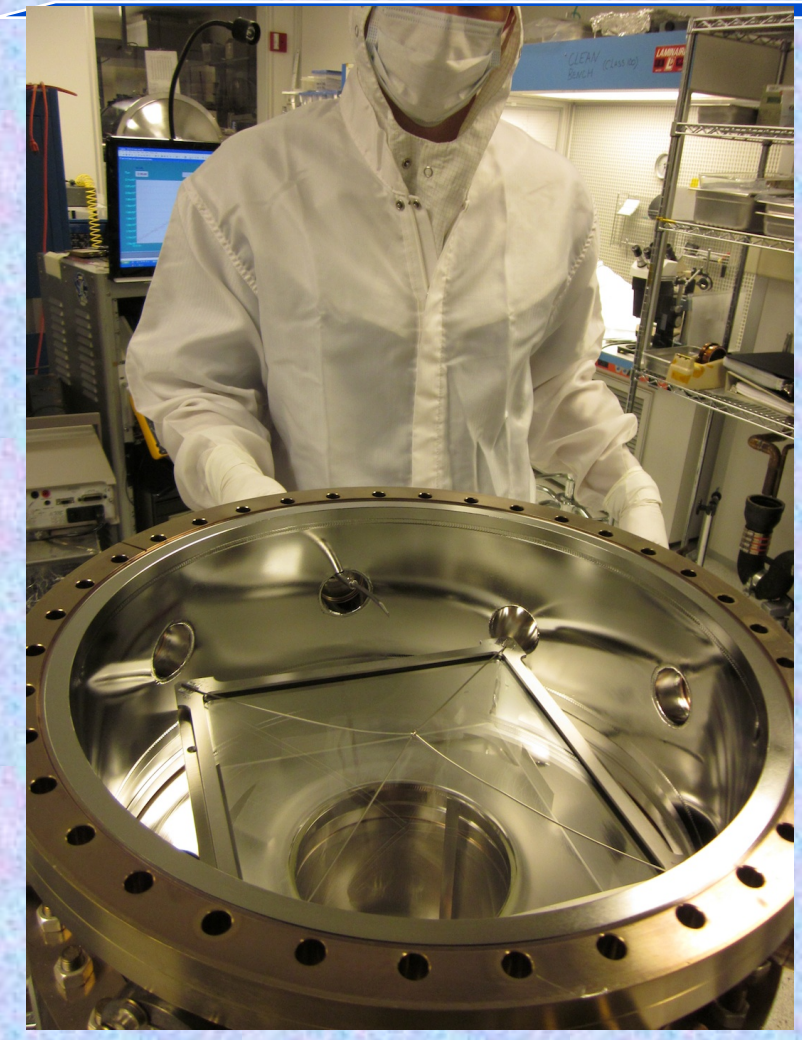
NiCr electrode border on B33

All the tooling is in place. We have wet cleaned, plasma cleaned, and evaporated NiCr on a window, and loaded into the holder for photocathode processing.



Plasma cleaning

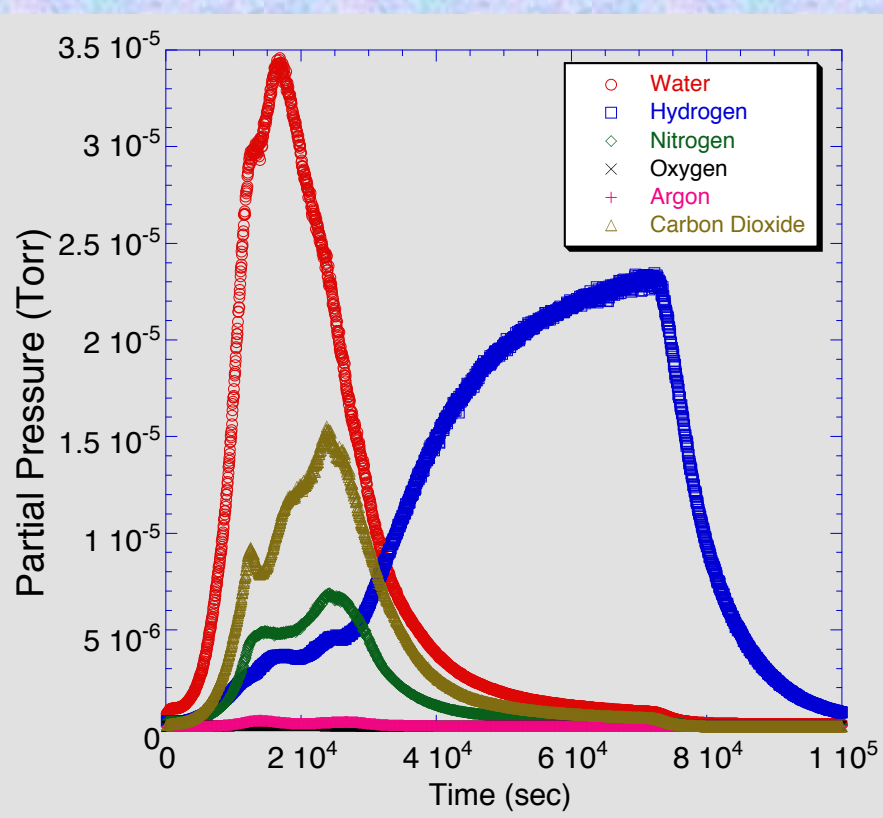
8” Photocathode Processing & System Load

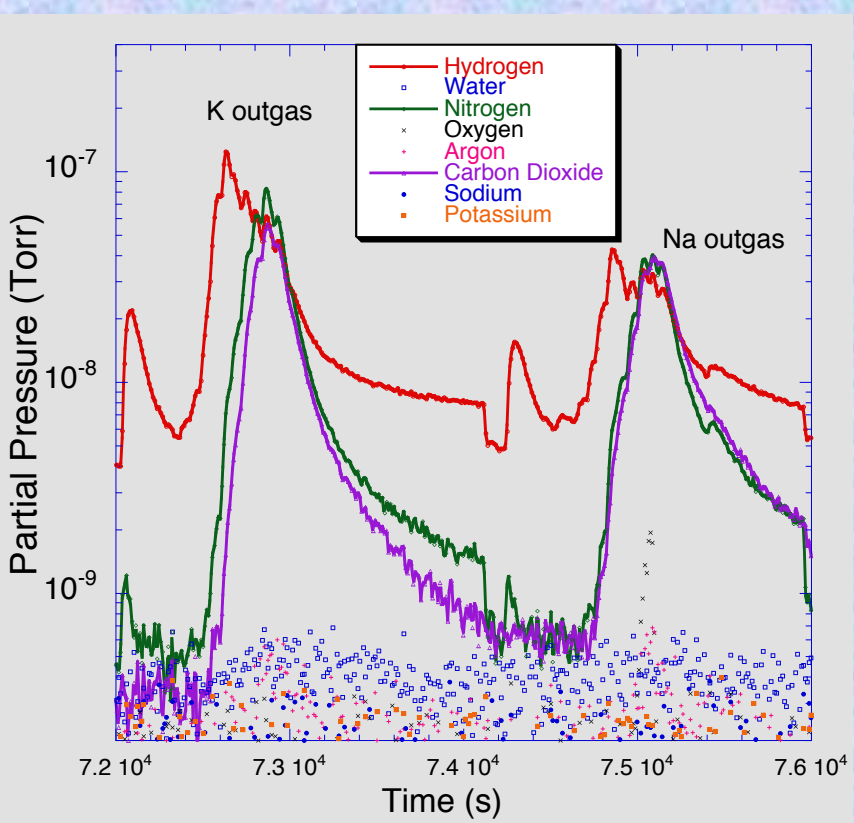


8.7” window loaded

- 8” PC/Seal Test Chamber
  - *<10^{-9} Torr base vacuum,*
  - *RGA operational, fully baked*
- 5mm thick, 8.7” polished B33 window
  - *NiCr border*
  - *electroded with “X” pattern*
- Oxygen plasma clean,
- baked at 365°C for 16 hrs
- Used larger 40mm alkali sources.
- Deposited Na_2KSb photocathode
- RGA record for entire process
- Cathode everywhere
  - except extreme corners

8” Na_2KSb Process #3A Preparations

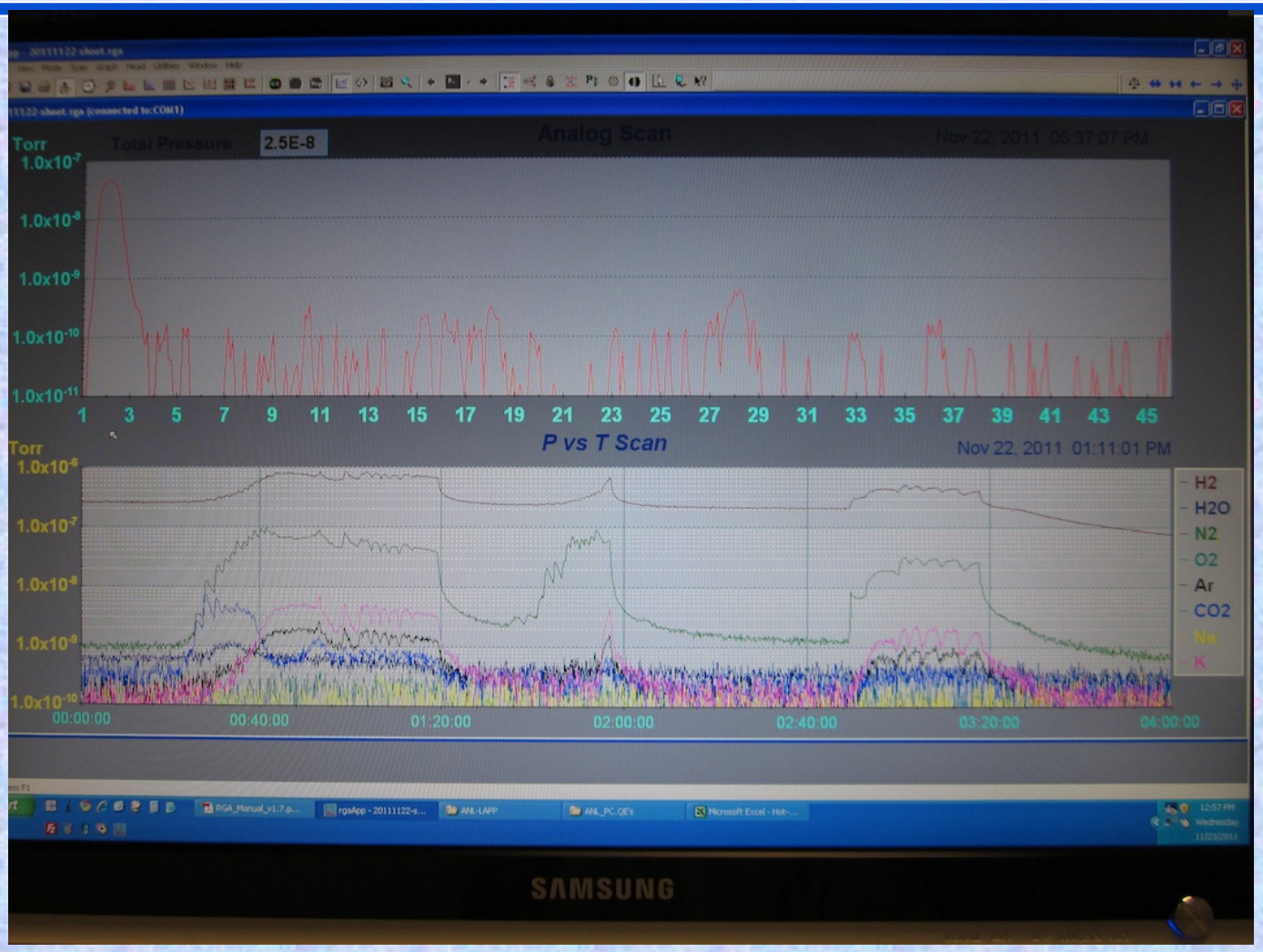




Bakeout

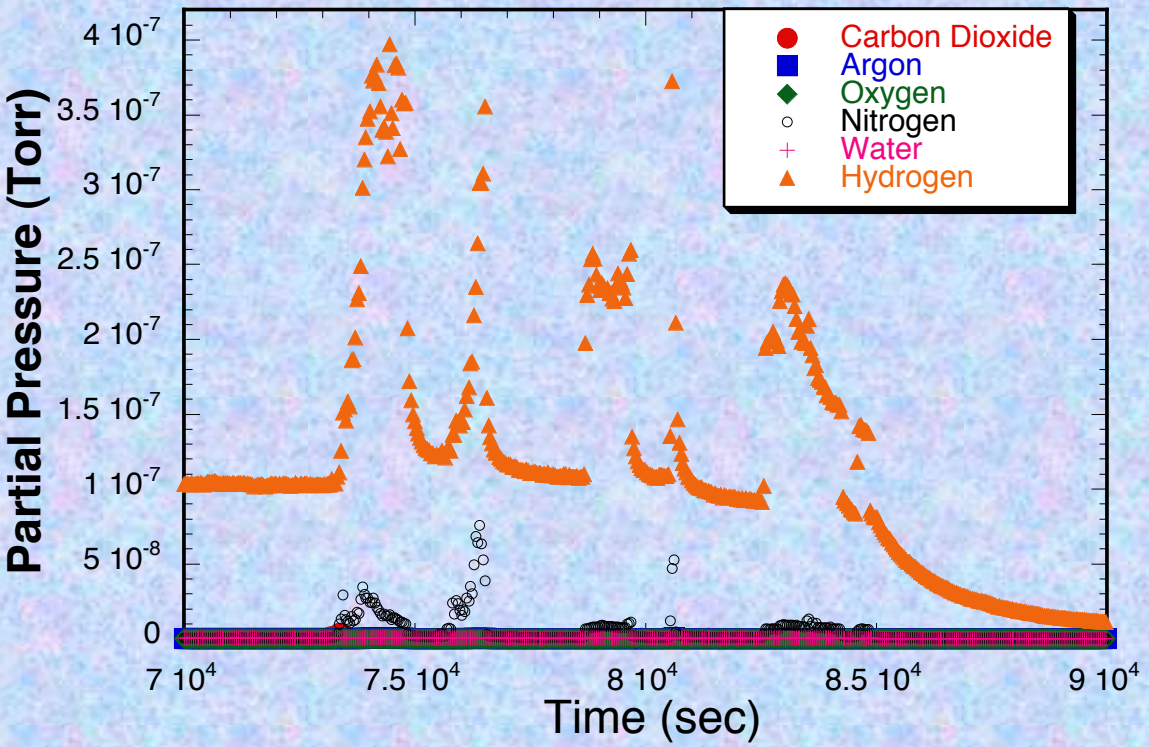
Alkali Outgas

Photocathode Deposition Outgassing

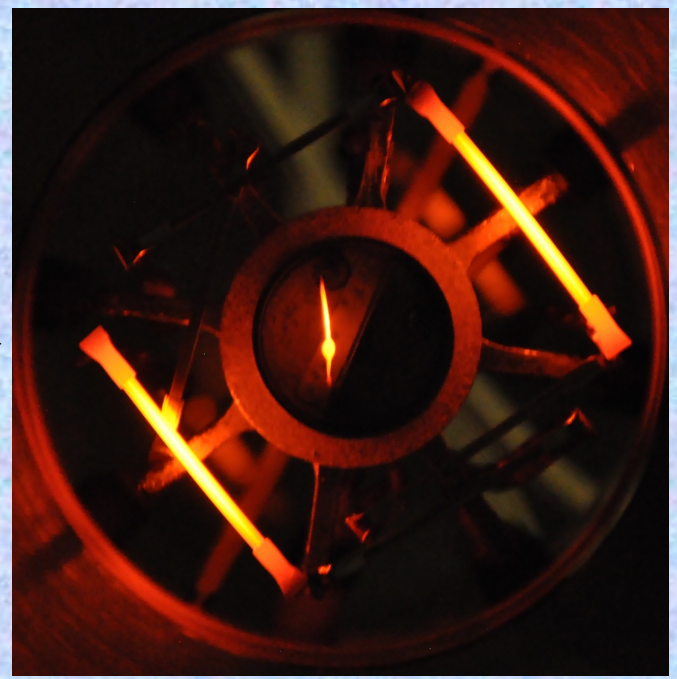


K Sb **Na** **K Sb**

8” Na_2KSb Process #3A

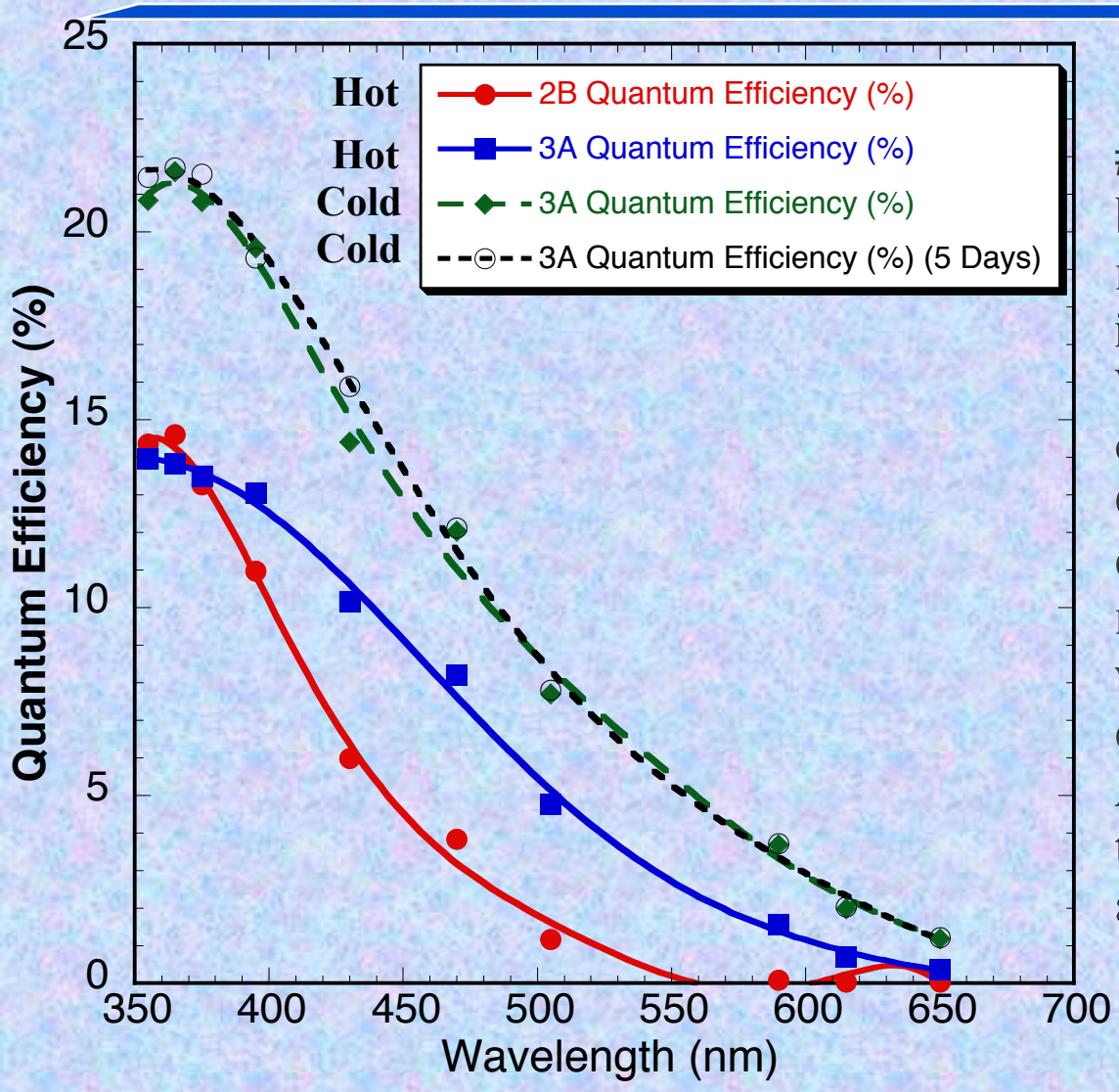


Cathode Shoot Outgassing



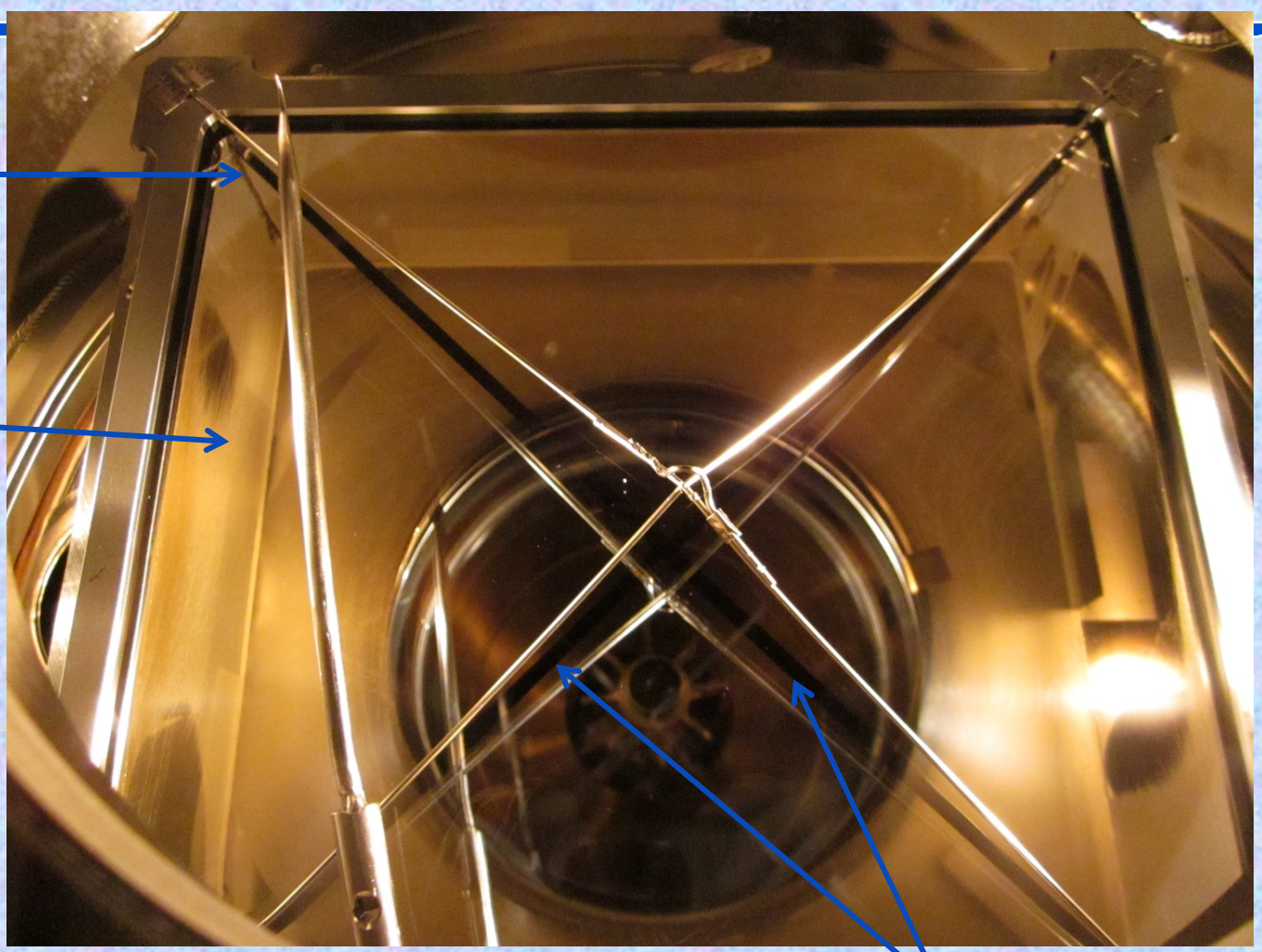
Alkali / Sb sources in action

8” -Na_2KSb Bialkali Processing



#3 is a redder cathode than before, but we made this one much thicker which can be seen in the opacity of the cathode. We get a typical enhancement of the QE after cool-down. The QE remained stable over the 5 days after deposition. This is not corrected for the 5mm thick window transmission which we expect to be about 85%. Average PMT cathodes of this type peak at about 18% so we are above that.

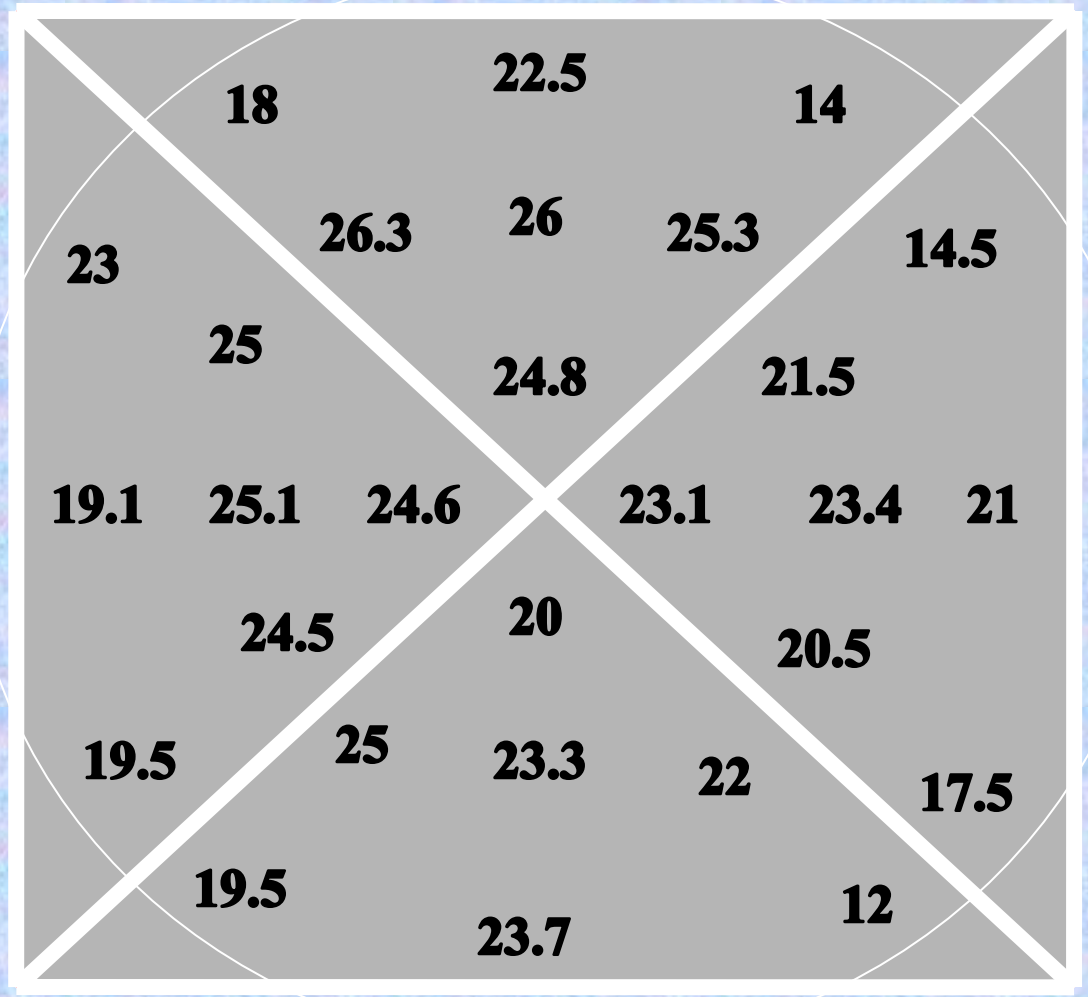
8” Na_2KSb Process #3A



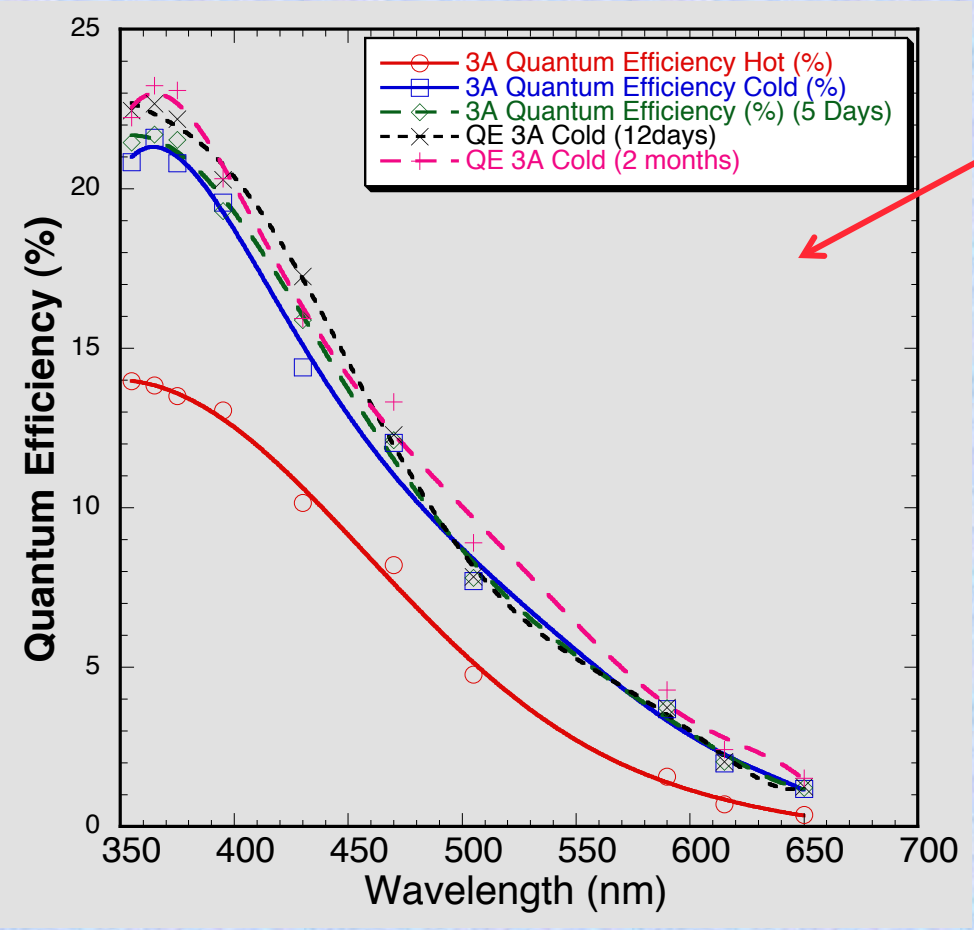
Window (hot) was lifted after process to simulate an indium hot seal procedure

8in #3A Photocathode Uniformity

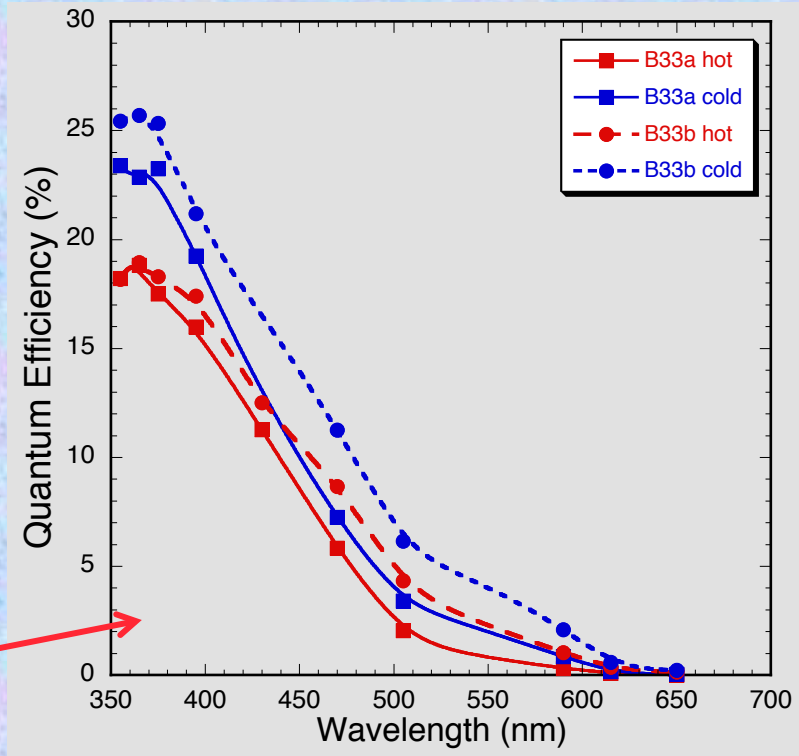
Majority of the area is within ±15% of the average QE, There is some obscuration by tooling in some places.



20cm - Na_2KSb Bialkali on Borofloat 33



Basic process is a co-evap technique. We get an enhancement of the QE after cool-down. The QE has remained stable over the 2 months since deposition.



Smaller 31mm windows give similar results (deposited in different process tank)

20cm PhotoCathode Test Chamber & Sealed Tube Device Process Tank

Process Tank Now In Conditioning Bake

Sealed Tube Device Process Tank

MCP conditioning, photocathode process and transfer seal.

20cm PhotoCathode Progress Summary

- 8” PC/Seal Test Chamber
  - *<10^{-9} Torr base vacuum, RGA operational, fully baked*
- 8” Sealed Tube Process Tank
  - *<10^{-9} Torr base vacuum, RGA operational, will complete bake-out commissioning this week*
- 5mm thick, 8.7” polished B33 window, NiCr border with “X”
- Deposited Na_2KSb photocathodes on 8” windows
  - *Get comparable results to small sample windows*
  - *~25% with good uniformity and stability meets our needs*
  - *Can repeat successful process in different vacuum tanks with different hardware*
- RGA/pressure/temp/response record for entire process